

Growth and Characterization of InGaN/GaN core-shell structures by molecular beam epitaxy

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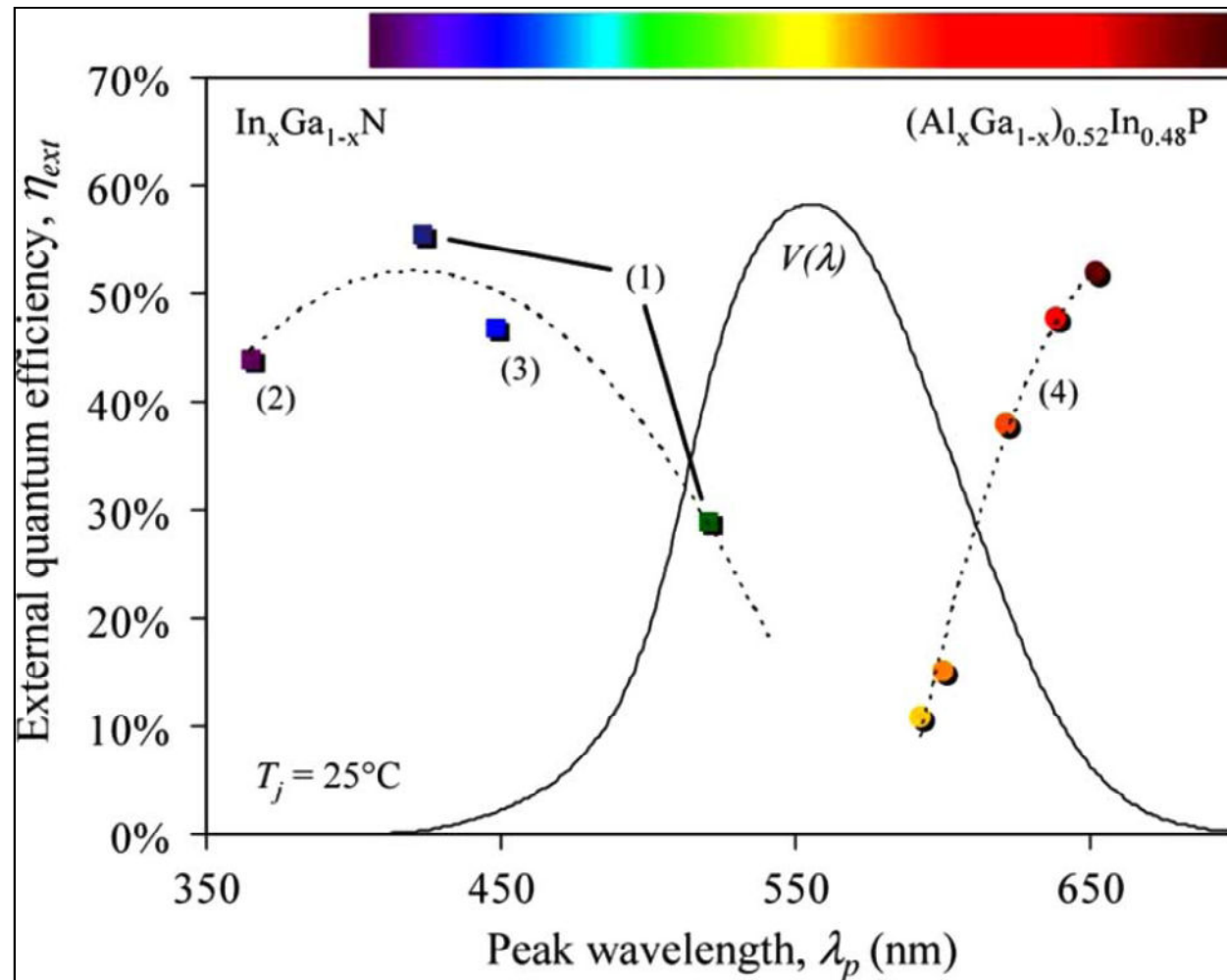
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slide 1



Introduction (1)



Efficiency drop in the green–yellow region in planar InGaN structures associated with:

- high defect density
- high spontaneous and piezoelectric polarization

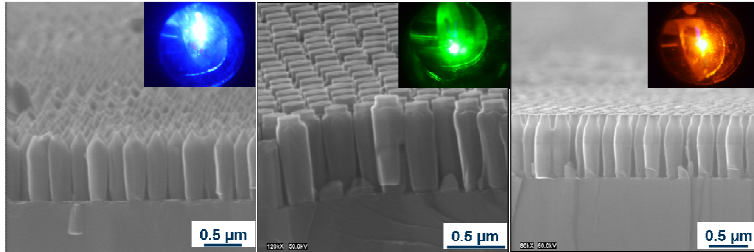
→ **solution:**
SAG NANOCOLUMNS
(NCs):

superior over self-assembled NCs in terms of homogeneity, processing and colour control

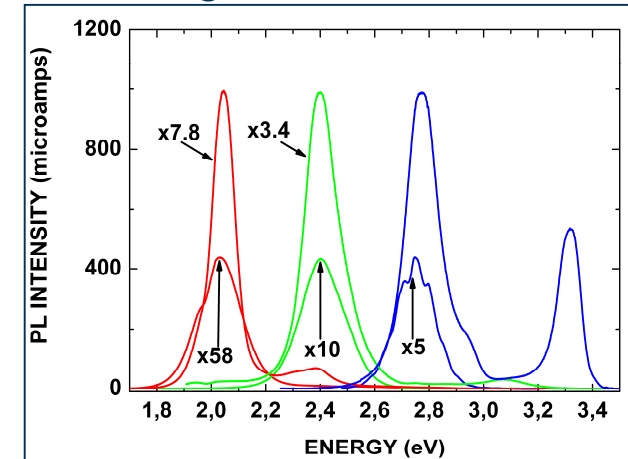
M. H. Crawford IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS, 15, 4, 2009

Introduction (2)

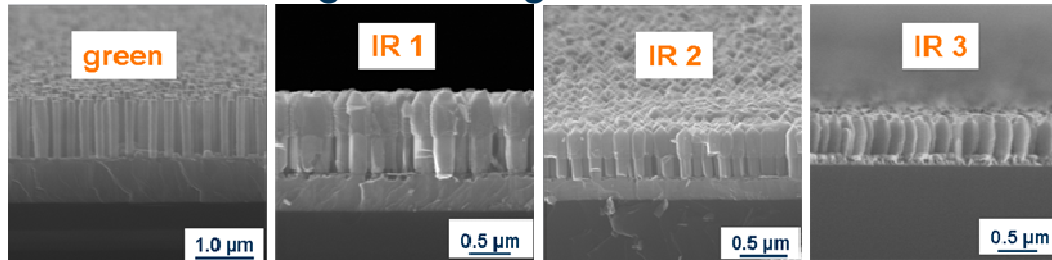
- selective area growth of (bulk) InGaN/GaN NCs allows for single color emission on **GaN/sapphire templates**



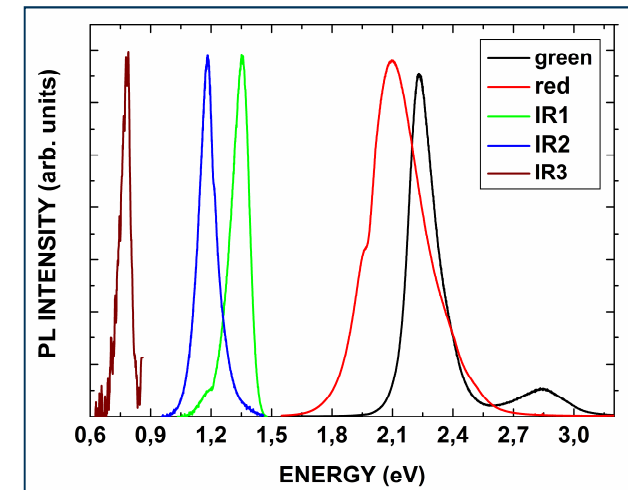
S. Albert, A. Bengoechea-Encabo et al., J. Appl. Phys. 113, 114306 (2013);
S. Albert et al., Appl. Phys. Lett. 102, 181103 (2013)



- SAG (bulk) InGaN/GaN NCs with an In content of up to 100 % were grown on **Si(111)** → PL-IQE up to 30% in the green range

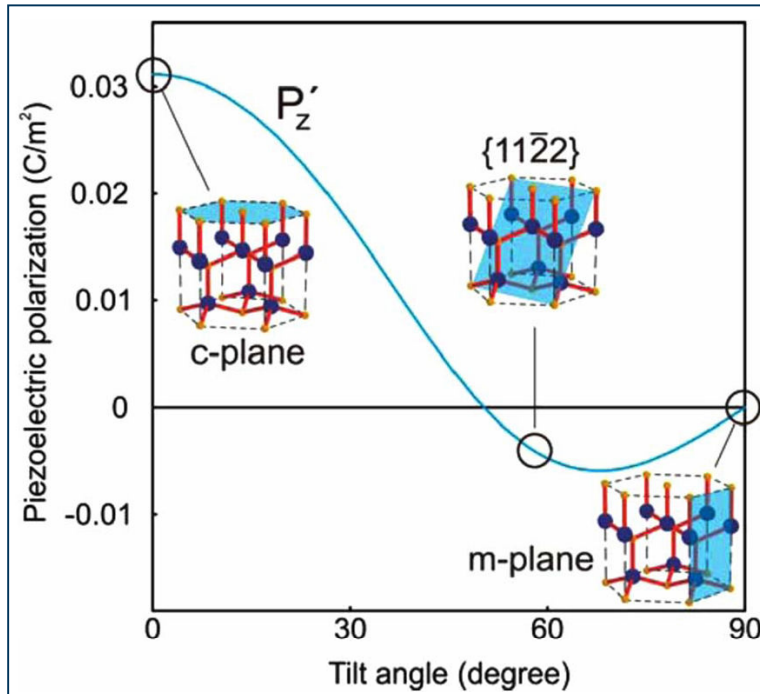


- still polarization effects due to growth on c-plane
solution: growth along semi-polar or non-polar direction



S. Albert, A. Bengoechea-Encabo et al., Nanotechnology 24, 175303 (2013)

Introduction (3)



- growing active region on semi-polar or non-polar facets
↓
reduces the polarization effects in wurtzite materials
- problem: high defect density in affordable non- and semipolar substrates

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Solution:

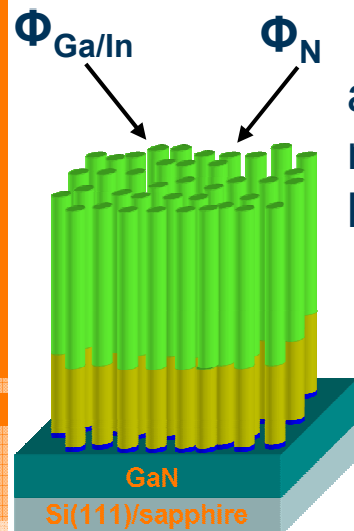
- Free standing non-polar HVPE substrates → **very expensive** ☹
- Growth of active material on semipolar facets of c-plane GaN NCs
[*S. Albert, A. Bengoechea-Encabo et al. Appl. Phys. Lett., 100, 23 (2012)*]
- Find new ways to get high quality substrates → coalescence of NCs with very high quality
[*S. Albert, A. Bengoechea-Encabo et al., Appl Phys. Lett., accepted*]
- Growth on non-polar m-plane sidewalls of GaN NCs → **InGaN core-shell**

Introduction (4)

- growth of InGaN/GaN core-shell structures already achieved some years ago using MOCVD [**Fang Qian, Yat Li, Silvija Gradecak, Deli Wang, Carl J. Barrelet, Charles M. Lieber, Nanoletters, 4, 10, (2004)]**
- Why bother to grow InGaN/GaN core-shell structures by PA-MBE?

potential for high(er) In-content core-shell structure → may allow for core-shell RG(Y)B emitters and tandem solar cells

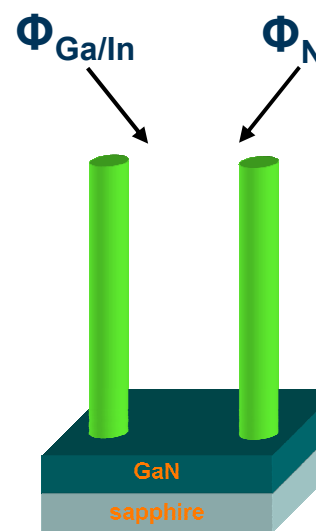
- approach:



axial

axial InGaN/GaN structures need shadowing effects for keeping selectivity

small pitch needed



core-shell

shadowing has to be prevented to allow for growth on m-plane

high pitch needed
long NCs needed → use of micro-columns

outline

- Limitation of bottom up SAG by PA-MBE
- InGaN core-shell growth on etched GaN pillars
- InGaN core-shell growth on MOVPE grown pillars
- Potential of PA-MBE for high In-content core-shell structures
- Summary